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(54) Apparatus for making unvulcanised rubber tape

(57) An apparatus for making a very thin unvulcanised rubber tape (G) having a finished thickness T0 in a range of from 0.3 to 1.5 mm, comprises: an extruder (3) comprising a passage (14) for unvulcanised rubber defining an outlet (5) for the extruded unvulcanised rubber; and a pair of calender rollers (19U,19L) disposed near said outlet for adjusting the thickness of the extruded unvulcanised rubber passing therebetween, the passage (14) being made up of a transforming part (15A) having an inlet for the unvulcanised rubber at its upstream-side end and a thinning part on the downstream side thereof defining said outlet at its downstream-side end, the transforming part (15A) gradually changing in the cross sectional shape from a circle to a flat shape in the lower course of the passage, the thinning part having a flat cross sectional shape and gradually decreasing in the thickness in the lower course of the passage, and the following relationships are satisfied

$0.7XW0 \leq WA \leq 1.0XW0$
$1.5XT0 \leq TA \leq 10XT0$
$WA < W2 < W1+0.2XL$
$P > 40$ kgf/sq.cm.

wherein

W1: width of said inlet,
WA & TA: width and thickness of the outlet,
L: length of the transforming part,
W2: width of the transforming part at its downstream-side end,
P: pressure of the unvulcanised rubber flowing into said inlet.

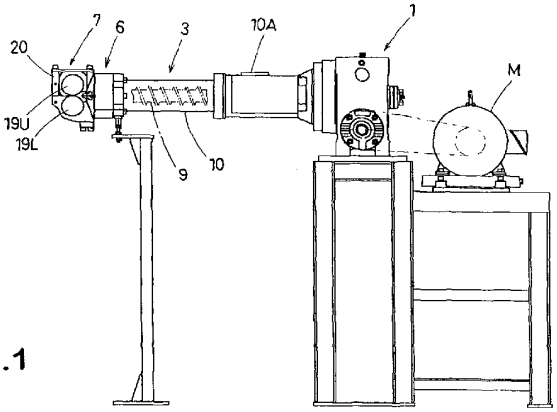

Fig.1

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Description

[0001] The present invention relates to an apparatus for making a thin unvulcanised rubber tape having a thickness in a range of from 0.3 to 1.5 mm.

[0002] Conventionally, unvulcanised rubber tyres are made of unvulcanised rubber components having various shapes and sizes. As the unvulcanised rubber components are formed by extruders, the number and sizes of the extruders are depend on the maximum size and the number of the kinds of the rubber components. Usually, at least several extruders which are relatively large-sized are required.

[0003] In recent years, in order to decrease the number and size of extruders to decrease the plant size and to establish a flexible manufacturing system, it was proposed to make a pneumatic tyre by winding an unvulcanised rubber tape G around a drum directly or indirectly thereon instead of applying a rubber component. For example, as shown in Fig.7 which shows a tread rubber B having a trapezoidal cross sectional shape, a rubber tape G is overlap-wound across the width thereof. Therefore, on the surface of the formed rubber component B or the windings of the tape G, an uneven part is formed due to the edges C of the windings of the tape G. Such unevenness of the surface can be prevented by using a very thin rubber tape having a thickness of 0.3 to 1.5 mm.

[0004] It is not difficult to decrease the thickness of the unvulcanised rubber in itself. The thickness can be easily decreased by rolling, but due to the elasticity and adhesiveness, it is difficult to stably obtain a constant thickness without breakage. Further, it is also difficult to obtain a constant width. As a result an additional work to cut the edges of the rolled rubber tape into the predetermined width is necessitated.

[0005] It is therefore, an object of the present invention to provide an apparatus which can stably make an unvulcanised rubber tape with accuracy in width and thickness although the thickness is in a very small range of 0.3 to 1.5 mm.

[0006] According to the present invention an apparatus for making an unvulcanised rubber tape comprises an extruder comprising a passage for unvulcanised rubber having an outlet for the extruded unvulcanised rubber, and a pair of calender rollers disposed near the outlet for adjusting the thickness of the extruded unvulcanised rubber passing therebetween, wherein the passage is made up of a transforming part having an inlet for the unvulcanised rubber at its upstream-side end, and a thinning part on the downstream side thereof defining the above-mentioned outlet at its downstream-side end, the transforming part gradually changes in the cross sectional shape from a circle to a flat shape in the lower course of the passage, the thinning part has a flat cross sectional shape and gradually decreases in the thickness in the lower course of the passage, and a width W0 and a thickness T0 of the unvulcanised rubber tape, a width W1 of the inlet, a width WA and a thickness TA of the outlet, a length L of the transforming part, a width W2 of the transforming part at its downstream-side end, and a pressure P of the unvulcanised rubber flowing into the inlet satisfy the following relationships

$$0.7XW0 \leq WA \leq 1.0XW0$$

$$1.5XT0 \leq TA \leq 10XT0$$

$$WA < W2 < W1+0.2XL$$

$$P > 40 \text{ kgf/sq.cm.}$$

[0007] An embodiment of the present invention will now be described in detail in conjunction with the accompanying drawings, in which:

Fig.1 is a side view of an apparatus for making an unvulcanised rubber tape according to the present invention;
Fig.2 is a cross sectional view of a tip part of the extruder thereof taken along a plane perpendicular to the widthwise direction of the tape;
Fig.3 is a cross sectional view of the tip part of the extruder taken along a plane parallel to the widthwise direction of the tape;
Fig.4 is a cross sectional view similar to Fig.2 but a throttle ring is provided in the passage;
Fig.5 is a perspective view showing the change of the cross sectional shape of the unvulcanised rubber;
Fig.6 is a diagram showing the unvulcanised rubber tape; and
Fig.7 is a cross sectional view showing a rubber component made by winding an unvulcanised rubber tape.

[0008] In the drawings, apparatus 1 for making an unvulcanised rubber tape according to the present invention comprises an extruder 3 and a pair of calender rollers 19U and 19L. An unvulcanised rubber tape G to be made by the apparatus 1 has, as shown in Fig.6, a predetermined finished thickness T0 in a range of from 0.3 to 1.5 mm, and a predetermined finished width W0 in a range of from 5 to 50 mm.

[0009] The extruder 3 comprises a cylinder block 10 with a cylinder head 6, a worm screw 9 therein, an electric motor M for driving the worm screw 9, and a die 12 attached to the cylinder head 6.

[0010] The cylinder block 10 is provided with a hole 10H in which the worm screw 9 is disposed. The hole 10H extends to the front end of the cylinder block 10 to open thereat, while keeping the same circular cross sec-

tional shape. This opening 2 of the hole 10H is at a certain distance J from the front end of the worm screw 9 so as to form a rubber pool 17 therebetween. The rear end of the hole 10H is connected to an input port 10A for material rubber compound.

[0011] The worm screw 9 is connected to the electric motor M through a reduction gear.

[0012] The cylinder head 6 is fixed to the front end of the cylinder block 10 by means of bolts which penetrate through holes of a flange 10B formed at the front end of the cylinder block 10 and engage with threaded holes formed on the back face of the cylinder head 6. The cylinder head 6 is provided on the front face with a hollow part for mounting the die 12. The cylinder head 6 is provided with a hole 15 which extends from the rear end of the cylinder head 6 continuously from the hole 10H and opens at the rear end of the hollow part for mounting the die 12.

[0013] The die 12 has a main portion put in the above-mentioned hollow part and a tip portion protruding therefrom. The main portion has a shape to fit to that of the hollow part to engage each other as shown in Fig.2. To realise this, the cylinder head 6 can be split into at least two parts. The split face may be a plane positioned at the thickness centre of the hole 15. The die 12 has a hole 16 which extends from its rear end continuously from the hole 15 to its front end so as to open thereat defining an extruder outlet 5.

[0014] The above-mentioned holes 15 and 16 form a passage 14 for the unvulcanised rubber.

[0015] The sectional shape of the passage 14 gradually changes from a circle at the opening 2 to a flat shape at the extruder outlet 5, while gradually decreasing in sectional area S and height T in the thickness direction of the tape as shown in Fig.5.

[0016] In this example, the above-mentioned hole 15 comprises a transforming part 15A whose sectional shape changes continuously from the circle to a flat shape and a cylindrical part 15B whose sectional shape is a constant circle and which extends from the opening 2 to the transforming part 15A. The diameter of the cylindrical part 15B is the same as the opening 2. In the cross sectional shape of the transforming part 15A, a pair of parallel sides having the same length continuously increase in length from the upstream end to the downstream end of the transforming part 15A, and these sides each form an inclined flat plane which is substantially triangular. Between the ends of the parallel sides, two curved sides of a circular arc extend. The radius of the circular arc decreases continuously from the upstream end to the downstream end of the transforming part 15A.

[0017] At the downstream end of the transforming part 15A or the upstream end of the hole 16, the sectional shape already becomes a flat shape close to a flat rectangle rather than an oval due to its two parallel long straight sides. In the hole 16, the degree of change in the sectional area S and the degree of change in the height T are reduced in comparison with those in the transforming part 15A so as to decrease a residual stress in the extruded unvulcanised rubber GP. In the sectional shape of the hole 16, the two parallel long straight sides continuously decreases in the length and as a result, these straight sides each form an inclined flat trapezoidal plane. Between the ends of the straight sides, curved sides of a small radius arc extend. Thus, in this example, in the transforming part 15A, the height T is decreased at a constant rate. Also in the hole 16, the height T is decreased at a constant rate but smaller than that in the transforming part 15A. Similar to the height T, the sectional area S may be changed at a constant rate in each of the transforming part 15A and the hole 16. Thus, when only the passage 14 is considered, the border between the transforming part 15A and the hole 16 is regarded as a changing point of the rate of the decrease in the height T.

[0018] Near the extruder outlet 5, the upper and lower calender rollers 19U and 19L are disposed to adjust the thickness and width of the unvulcanised rubber Gp extruded from the extruder outlet 5. The rollers 19U and 19L are supported by a frame 20 fixed to the cylinder head 6. The upper calender roller 19U and the lower calender roller 19L rotate at the same speed but in the opposite directions. It is important that the changes of the thickness and width by rolling are restricted to small values in order to stably make a very thin unvulcanised rubber tape with accuracy.

[0019] Here, it is very important that the width W0 and thickness T0 of the finished unvulcanised rubber tape G, the width WA and height TA of the extruder outlet 5, the width W1 of the transforming part 15A at its upstream-side end, the width W2 of the transforming part 15A at its downstream-side end, the length L of the transforming part 15A along its central axis, and the pressure P in the passage 14 measured on the upstream side of the transforming part 15A satisfy the following relationships:

$$W2 < W1+0.2XL$$

$$WA < W2$$

$$0.7XW0 \leq WA \leq 1.0XW0$$

$$1.5XT0 \leq TA \leq 10.0XT0$$

$$P > 40 \text{ kgf/sq.cm}$$

[0020] If the width W2 is more than W1+0.2XL and/or the width WA is more than the width W2, then the flow of rubber to both side edges of the passage 14 becomes

not enough and it becomes difficult to obtain the constant width WO.

[0021] If the width WA is less than 0.7 times the width W0 of the finished rubber tape G, as the amount of the roll processing excessively increases, the dimensional accuracy especially accuracy in the width and quality of the finished rubber tape G deteriorate.

[0022] It is preferable that the width WA is set in a range of from 0.8 to 0.9 times the width W0.

[0023] If the height TA is less than 1.5 times the thickness T0 of the finished rubber tape, then undulation is liable to occur on the rubber tape G causing unevenness in the thickness. If the height TA is more than 10 times the thickness T0, then the amount of the roll processing excessively increases and it becomes difficult to make the width stable.

[0024] It is preferable that the thickness TA is in a range of from 3 to 5 times the thickness T0.

[0025] If the inner pressure P is less than 40 kgf/sq. cm, then the width of the extruded rubber Gp is varied by variation of the delivery pressure of the screw and as a result the width of the rolled tape is also varied.

[0026] It is preferable that the pressure P is in a range of more than 60 kgf/sq.cm.

[0027] For example, when the thickness T0 is 0.8 mm and the width W0 is 22 mm, the widths W1 and W2 are 30 mm, the length L is 26.5 mm, the width WA is 18.0 mm, the height TA is 3.0 mm, the inner pressure P is 50 to 80 kgf/sq.cm, the diameters of the calender rollers are 80 mm.

[0028] Fig.4 shows a state of the extruder provided between the passage 14 and the worm screw 9 with a throttle 23 in order to stabilise the pressure P of the unvulcanised rubber flowing into the passage 14 from the worn screw 9. In this example, the throttle 23 is defined by the aperture of a throttle ring which is disposed in a circular groove 24 formed along the joint between the cylinder head 6 and the cylinder block 10. The diameter D1 of the aperture is set in a range of from 0.5 to 0.2 times the inside diameter D of the hole 10H. In the state shown in Figs.2 and 3, a ring whose inside diameter is the same as the passage 14 and rubber pool 17 is disposed in the groove.

[0029] Between the above-mentioned groove for mounting the throttle ring and the worm screw, there is provided with a pressure sensor 22 for the delivery pressure of the worm screw. The output of the sensor 22 is given to a controller 21 for the electric motor M and the rotational speed thereof is controlled according to the delivery pressure so that the pressure becomes constant.

[0030] As described above, in the present invention, the shape of the passage and the pressure are specifically defined. Therefore, the amount of the roll processing to the extruded rubber is decreased. Further, due to the increased pressure and the specific shape, influence of variation of the pressure on the extruded rubber such as variation of the thickness, width and residual stress can be decreased. Also the magnitude of the residual stress is decreased. As a result, it becomes possible to stably make a very thin unvulcanised rubber tape with accuracy in both width and thickness.

Claims

1. An apparatus for making an unvulcanised rubber tape (G) having a finished thickness T0 in a range of from 0.3 to 1.5 mm, comprising an extruder (3) **characterised by** a passage (14) for unvulcanised rubber defining an outlet (5) for the extruded unvulcanised rubber, and a pair of calender rollers (19U, 19L) disposed near said outlet (5) for adjusting the thickness of the extruded unvulcanised rubber passing therebetween, said passage (14) being made up of a transforming part (15A) having an inlet for the unvulcanised rubber at its upstream-side end, and a thinning part on the downstream side thereof defining said outlet at its downstream-side end, said transforming part (15A) gradually changing in cross sectional shape from a circle to a flat shape in the lower course of the passage (14), said thinning part having a flat cross sectional shape and gradually decreasing in thickness in the lower course of the passage, said thickness T0 and a width of the unvulcanised rubber tape, a width W1 of said inlet, a width WA and a thickness TA of said outlet, a length L of the transforming part (15A), a width W2 of the transforming part at its downstream-side end, and a pressure P of the unvulcanised rubber flowing into said inlet satisfy the following relationships

$$0.7XW0 \leq WA \leq 1.0XW0$$

$$1.5XT0 \leq TA \leq 10XT0$$

$$WA < W2 < W1+0.2XL$$

$$P > 40 \text{ kgf/sq.cm.}$$

2. An apparatus according to claim 1, **characterised in that** in said thinning part, the thickness decreases at a substantially constant rate, but in the transforming part (15A), the thickness decreases at a rate larger than said substantially constant rate.

3. An apparatus according to claim 1, **characterised in that** said extruder includes a screw (9) for pushing the unvulcanised rubber into said inlet of said passage (14), and a throttle is disposed between said screw (9) and said inlet of said passage (14).

4. An apparatus according to claim 1, **characterised in that** said extruder includes a screw (9) for pushing the unvulcanised rubber into said inlet of said passage, a throttle is disposed between said screw and said inlet of said passage, and a sensor for the delivery pressure of the screw, and a controller for a motor driving the screw which, according to an output of the sensor, controls the rotational speed of the screw to maintain the delivery pressure over a predetermined level.

5. An apparatus according to claim 1, **characterised in that** said extruder includes a screw (9) for pushing the unvulcanised rubber into said inlet of said passage (14), a sensor for the pressure of the unvulcanised rubber flowing into said inlet from the screw, and a controller for a motor driving the screw which, according to an output of the sensor, controls the rotational speed of the screw to stabilise the pressure.

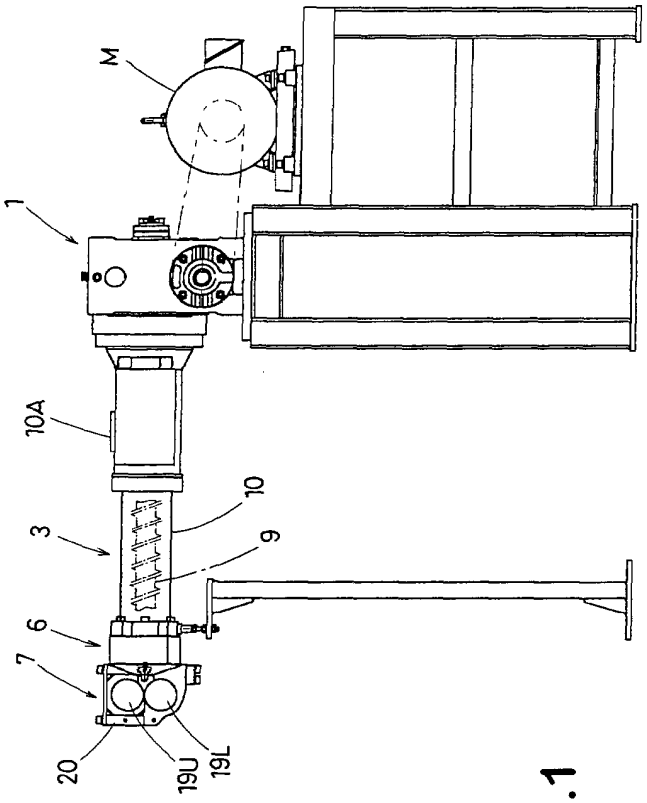

Fig.1

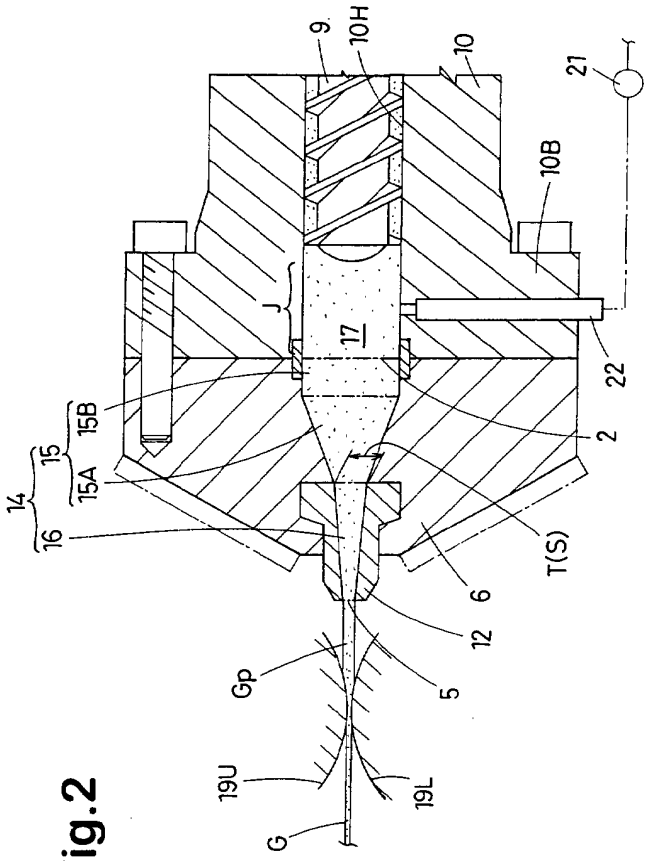

Fig.2

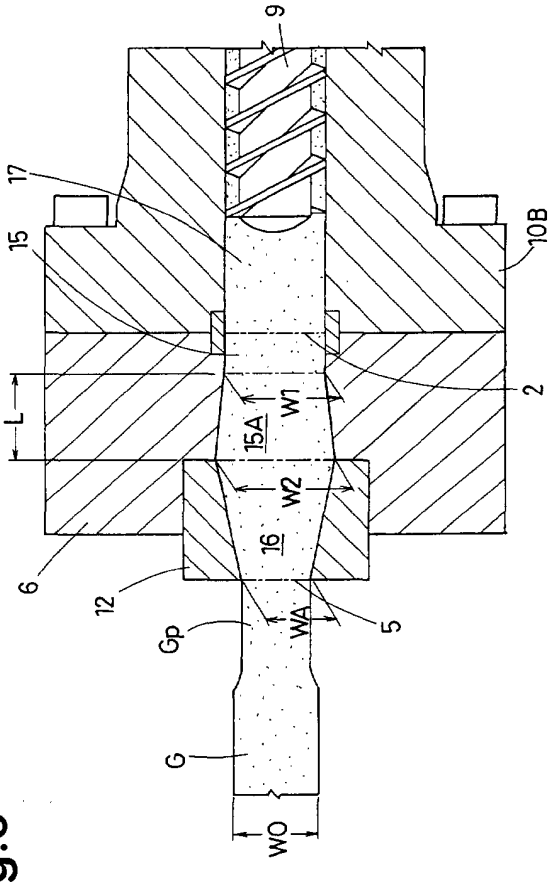

Fig.3

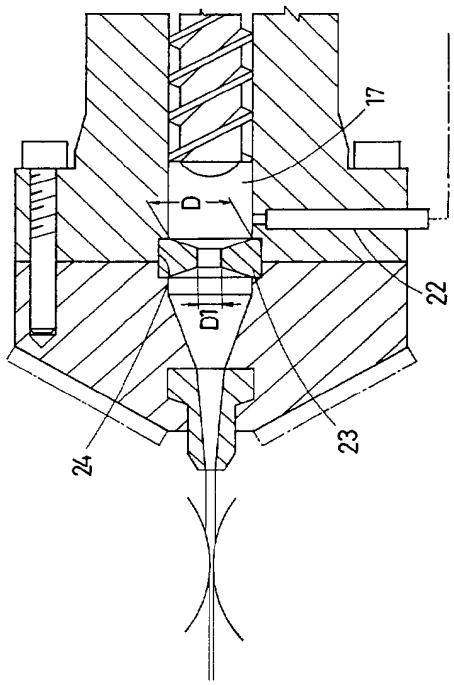

Fig.4

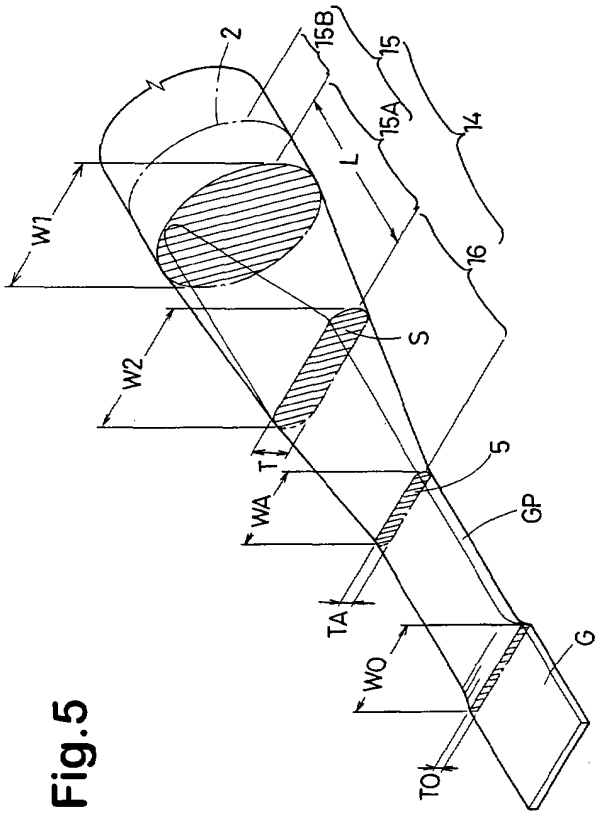

Fig.5

Fig.6

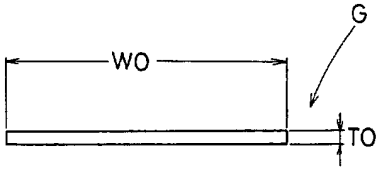

Fig.7